Recommendation - Reduce Compressor Operating Pressure

Recommended Action

Cut back on the operating pressure of the compressors from 125 psig to 110 psig. The minimum operating pressure needed is 85 psig.

Estimated Energy Savings = 448.5 MMBtu/yr
Estimated Energy Cost Savings = $3,552/yr
Estimated Demand Savings = 223.8 kW-months/yr
Estimated Demand Cost Savings = $2,175/yr
Estimated Total Cost Savings = $5,727/yr
Estimated Implementation Cost = $20
Simple Payback = less than one month

Anticipated Savings

The basic horsepower required by a compressor is determined by the capacity (volume of the intake air flow compressed) and the pressure (amount of stored power, psig). For every pound of pressure decrease in air compressors (100-150 psig range), a decrease of about 0.5% in power consumption is possible[1].

Currently, compressor air is being generated at 125 psig. The compressors operate for approximately 7000 hours/yr. Generally, only two of the three compressors at the facility are operating at one time. The annual energy savings that can be realized by reducing the current operating pressure on these two compressors are estimated as follows:

$$ES = N \times \Delta P \times C1 \times HP \times HRS \times C2 \times C3 / EFF$$

where

N	=	number of compressors
ΔP	=	change in operating pressure, psig
C1	=	conversion factor, 0.005/psig
HP	=	horsepower of compressor motor
HRS	=	annual hours of operation
C2	=	conversion factor, 0.746 kW/hp
C3	=	conversion factor, 0.003413 MMBtu/kWh
EFF	=	compressor motor efficiency (assumed to be 90%)

Thus, the estimated savings, ES, can be calculated as follows:

$$ES = (2)(15)(.005)(150)(7{,}000)(.746)(.003413) / (.9)$$
$$ES = 448.5 \text{ MMBtu/yr}$$

The annual cost savings, CS, can be estimated as follows:

$$CS_E = ES \times (\text{unit cost of electricity})$$

---

[1] Chemical Engineering Progress, "Optimize Your Plant's Compressed Air System", February 1995, pp. 35-39.

CS_E = (448.5 MMBtu/yr)(\$7.92/MMBtu)
CS_E = \$3,552/yr

A reduction the compressor operating pressure will also result in a reduction in electrical demand. The demand savings, DS, can be estimated as follows:

DS = (N x ΔP x C1 x HP x C2/EFF) x 12 months/year

Thus, a 15 psig reduction in the compressor operating pressure will result in the following demand savings:

DS = (2)(15)(.005)(150)(0.746)/(.9) x 12
DS = 223.8 kW-months/yr

The demand cost savings can then be calculated as follows:

CS_D = DS x (unit cost of electrical demand)
CS_D = (223.8 kW-months/yr)(\$9.72/kW-months)
CS_D = \$2,175/yr

Implementation Cost

Assuming that the operating pressure can be decreased without having to make any other modifications to the existing compressor system, the implementation cost associated with this recommendation will only be labor costs. A half an hour per compressor should be sufficient time to adjust the operating pressure, with a cost of approximately \$40. Therefore, the payback time in which the energy savings can be realized is less than one month.

Note: *the client was previously advised by a vendor to operate compressors at maximum capacity. The IAC contacted the manufacturer (Gardner-Denver) of the client's compressors. According to the manufacturer's technical representative, the 150 hp screw-type compressors that the client operates may be operated at the pressures suggested by this assessment recommendation with no adverse effects on the durability of the units.*

Recommendation - Improve Overall Power Factor

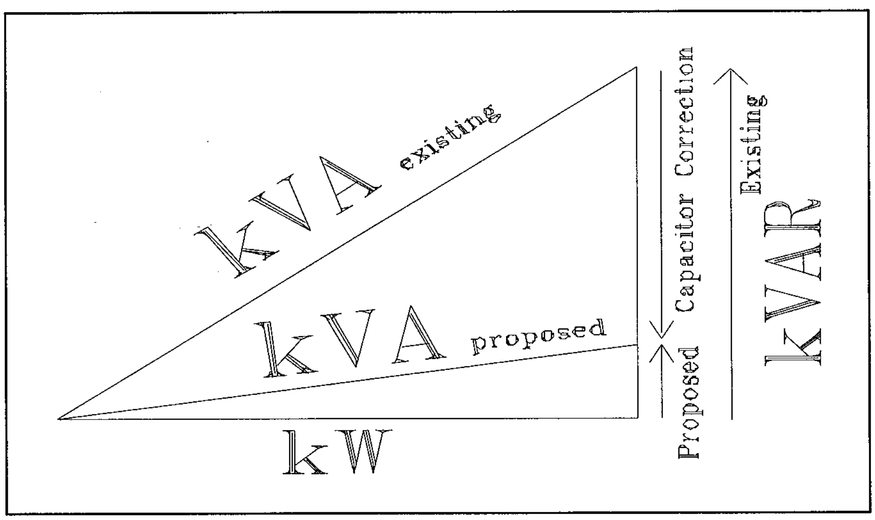
Recommended Action

Install capacitors to correct for low power factor.

Estimated Cost Savings = $45,615/yr
Estimated Implementation Cost = $47,600
Simple Payback = 13 months

Background

Power factor is a way of quantifying the reaction of alternating current (AC) electricity to various types of electrical loads. Inductive loads, such as motors and fluorescent lamp ballasts, cause the voltage and current to shift out of phase. The utility company must supply additional power, measured in kilovolt-amps (kVA), to make up for the phase shift. The total power requirement of the load is made up of two components, the resistive, or real, component and the reactive component. The resistive component, measured in kilowatts (kW) by a watt meter, does the useful work. The reactive component, measured in reactive kilovolt-amps (kVAR), represents the current needed to produce the magnetic field for the operation of a motor or other inductive device. This component does no useful work, is not registered on a power meter, but contributes to the heating of generators, transformers and transmission lines, constituting a loss for the utility company.



Components of Electrical Power

The ratio of real, useable power (kW) to apparent power (kVA) is known as the power factor. To reduce reactive losses, the user should increase the power factor to a value as close to unity (1.0) as is practical for the entire manufacturing plant. Utility companies often assess a power factor charge when the power factor falls below a specified level because more apparent power must be supplied as the user's power factor decreases.

For example, assume that a manufacturing plant has an average annual power factor of 0.78. Power factor of 0.78 means that for every 78 kW of usable power that the plant requires, the utility must supply 78 kW/PF or 100 kVA. If the plant's power factor is changed from 0.78 to 0.95, then for every 78 kW demanded by the plant, the utility need only supply 78 kW/0.95 or 82 kVA.

The utility supplying electricity to your facility requests that you maintain a power factor as near unity as possible at all times, and assesses a power factor charge when the power factor is below 80%.

Capacitor banks can be installed to decrease the reactive power (kVAR) and thus the apparent power. Capacitors draw current which leads the voltage, while inductive loads draw current which lags the voltage. The net result is that the current in the supply line is brought more closely in phase with the supply voltage. A power factor of 1.0 indicates that the current and the voltage are exactly in phase.

Capacitors can be installed at any point in the electrical system and will improve the power factor between the point of application and the power source. Capacitors can be added at each piece of equipment, ahead of groups of small motors, or at main services. The advantages and disadvantages of each type of installation are highlighted below.

Table 1: Types of Capacitor Installation

Type of Capacitor Installation[1]	Advantages	Disadvantages
Individual Equipment	Increased load capabilities of distribution system	Smaller capacitors cost more per kVAR than larger units
	Better voltage regulation	
Grouped Equipment	Increased load capabilities of the service	Switching means may be required to control the amount of capacitance
Main Service	Low installation costs	Switching means will usually be required to control the amount of capacitance
		Does not improve load capabilities of distribution system

Using the geometric relationships between kW, kVA, and kVAR as shown in the first figure, one can calculate the capacitance factor, CF, which is the reactance of the capacitors needed to adjust the power factor per kW of electrical power. The capacitance factor, CF, is given in units of kVAR/kW in the relationship given below.

$$CF = TAN\left(COS^{-1}(PF_c)\right) - TAN\left(COS^{-1}(PF_p)\right)$$

where

TAN = tangent function

[1] Power Factor Correction, A Guide for the Plant Engineer, Commonwealth Spraque Capacitor, Inc.

COS^{-1}	=	inverse cosine function
PF_c	=	current power factor, kW/kVA
PF_p	=	proposed power factor, kW/kVA

From power factor measurements that are posted on the utility bills the current power factor is 75% in July of 1997. The suggested power factor for your facility is 95%. Thus, the kVAR/KW of capacitors needed to increase the power factor to a level of 95% can be computed as follows:

$$CF = TAN(COS^{-1}(0.75)) - TAN(COS^{-1}(0.95))$$
$$CF = .553 \text{ kVAR/kW}$$

The following table, generated from the previous equation, provides the capacitance factor used to determine the amount of capacitance required to obtain the desired power factor.

Table 2: Power Factor Correction

Existing Power Factor	Corrected Power Factor 1.00	0.95	0.90	0.85	0.80	0.75
0.66	1.138	0.810	0.654	0.519	0.388	0.256
0.68	1.078	0.750	0.594	0.459	0.328	0.196
0.70	1.020	0.692	0.536	0.400	0.270	0.138
0.72	0.964	0.635	0.480	0.344	0.214	0.082
0.74	0.909	0.580	0.425	0.289	0.159	0.027
0.76	0.855	0.526	0.371	0.235	0.105	
0.78	0.802	0.474	0.318	0.183	0.052	
0.80	0.750	0.421	0.266	0.130		
0.82	0.698	0.369	0.214	0.078		
0.84	0.646	0.317	0.162	0.026		
0.86	0.593	0.265	0.109			
0.88	0.540	0.211	0.055			
0.90	0.484	0.156				
0.92	0.426	0.097				
0.94	0.363	0.034				
0.96	0.292					
0.98	0.203					
0.99	0.142					

For your facility, the monthly demand load during June of 1998 was approximately 2151 kW. The power factor correction as calculated above is 0.553. Using the correction factor, the amount of capacitance, KVAR, needed to obtain the desired power factor of 95% can now be determined:

$$kVAR = D \times CF$$

where

D	=	maximum annual demand, kW

$$CF = \text{correction factor, kVAR/kW}$$

Therefore

$$kVAR = (2151\ kW) \times (.553\ kVAR/kW)$$
$$kVAR = 1190\ kVAR$$

The cost savings can be calculated by multiplying the demand cost by the increased demand due to low power factor for each month.

$$CS = D_{pf} \times (\text{demand cost})$$

The increased billing demand due to low power factor, D_{pf}, is estimated as:

$$D_{pf} = D \times (PF_p - PF_c)$$

where

D = measured peak demand for the month, kW
PF_p = proposed power factor, kW/kVA
PF_c = current power factor, kW/kVA

An example for your facility in June of 1998 is:

$$D_{pf} = (2151\ kW) \times (0.95 - 0.75)$$
$$D_{pf} = 430.2\ kW$$

$$CS = (430.2\ kW) \times (\$10.89/kW)$$
$$CS = \$\ 4{,}685$$

The following table uses the capacitance amount of 1189 kVAR to calculate the potential cost savings for each month; it also gives the new power factor assuming 1189 kVAR is installed.

3: Summary of Costs Savings

Month & Year	Current Power Factor	Demand (kW)	New Power Factor	Total Cost Savings ($)
Jul-97	0.750	2151.0	0.950	4685.
Aug-97	0.750	2151.0	0.950	4685.
Sep-97	0.750	2003.0	0.961	4602.
Oct-97	0.740	1874.0	0.964	3475.
Nov-97	0.750	1760.0	0.979	3336.
Dec-97	0.760	1745.0	0.985	3248.
Jan-98	0.760	1803.0	0.981	3299.
Feb-98	0.750	1735.0	0.981	3315.
Mar-98	0.760	1798.0	0.982	3294.
Apr-98	0.730	1831.0	0.961	3499.
May-98	0.740	2036.0	0.951	3552.
Jun-98	0.750	2040.0	0.958	4625.
Total				**$45,615**

From the table above, it can be seen that a total yearly cost savings of $45,615/yr would be saved by correcting the lower power factor.

Implementation Cost

As calculated on the previous page, the installation of capacitors rated at 1190 kVAR would be required to correct for low power factor. The installation of these capacitors should increase the power factor to at least the desired level of 95%. The installed cost for capacitors is estimated as $40/kVAR, and therefore the implementation cost, IC, is estimated as:

IC = (1190 kVAR)($40/kVAR)
IC = $47,600

Therefore, the annual cost savings of $45,615/yr would pay for the implementation cost of $47,600 in about 13 months.

To determine the exact optimum power correction factor and the specification of the capacitors require engineering work beyond the scope of this report. It is recommended that additional professional advice be obtained from a capacitor supplier or an engineering firm. Finally, note that no energy savings can be attributed to this action; the savings are strictly monetary.

Note: this recommendation is calculated for only one meter (No. 6000002010001) at the facility. Complete records were not available for all of the many electric utility meters. If similar evaluations are carried out on other meters at the facility with low power factor, savings should increase.

Showcase Demonstration CASE STUDY

MOTOR CHALLENGE

a Program of the U.S. Department of Energy

THE CHALLENGE: IMPROVING SEWAGE PUMP SYSTEM PERFORMANCE

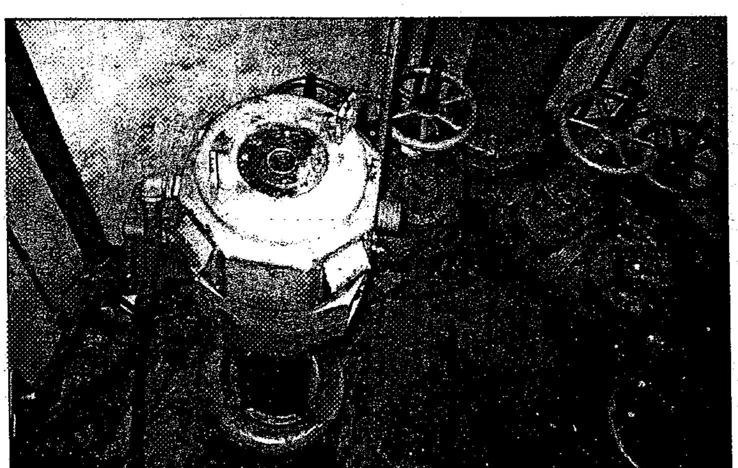
Summary

The Town of Trumbull was looking for a way to increase the energy and operating efficiency of its Reservoir Avenue sewage pump station. With the help of ITT Flygt Corporation, the town altered the existing pump system by adding a smaller pump and modifying the system control scheme. The changes reduced annual electricity consumption by almost 44 percent, or nearly 31,900 kWh, saving more than $2,600 per year. This Motor Challenge Showcase Demonstration project, which cost $12,000, has a simple payback of 4.6 years. The project demonstrates that an innovative pump selection and operating scheme can significantly reduce the operational costs of a sewage pumping station. The lessons learned from this successful project can be applied to Trumbull's other sewage pumping stations, further reducing the town's electricity consumption and costs, and to similar pumping stations throughout the United States.

Project Profile	
Industry:	Municipal Sewage System
Process:	Sewage Pumping
System:	Pump System
Technology:	Downsized pump, direct on-line pump controls

Background

Located just north of Bridgeport in southwestern Connecticut, the Town of Trumbull has a population of 32,000 and, with ten sewage pumping stations, a total raw sewage handling capacity of 3.3 million gallons per day. Each of the stations pump sewage to a main lift station where it is then pumped to a sewage treatment plant in Bridgeport.



Existing 40-hp Pump Motor

Project Overview

Built in 1971, the Reservoir Avenue Pump Station consisted of twin sewage handling pumps vertically mounted approximately 17 feet below the ground. The pumps were each equipped with a 40-hp direct drive, wound-rotor motor. Running at reduced speed, the pumps operated at a system duty point of approximately 850 gallons per minute (GPM) at 50.3 feet of total dynamic head (TDH). A control system using a wound rotor and variable resistance circuit technology was used to reduce pump speed to a constant 1320 revolutions per minute (RPM). To

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turn the pumps on and off based on the level of liquid in the sump, a bubbler-type level control system was used. The system used two continuously running compressors which supplied a small amount of air through a dip tube into the wet well. A pressure transducer mounted on the air supply line measured the pressure needed to overcome the wet well level.

The pump station handles approximately 0.34 million gallons (MG) of raw sewage per day. The original pumping processes consumed approximately 72,500 kWh of electricity annually, costing the Town of Trumbull $5,495.

Town of Trumbull

SIC: 4952

Service: Sewage Pumping

Location: Trumbull, Connecticut

Showcase Team Leaders:
Stefan Abelin, ITT Flygt Corporation
Paul Kallmeyer, Town of Trumbull
Three employees in the wastewater treatment department.

Energy Philosophy: All efforts should be made to ensure that energy saving measures are employed, as long as they do not reduce reliability and the payback period is reasonable. Never stop looking for those steps that save energy.

Project Team

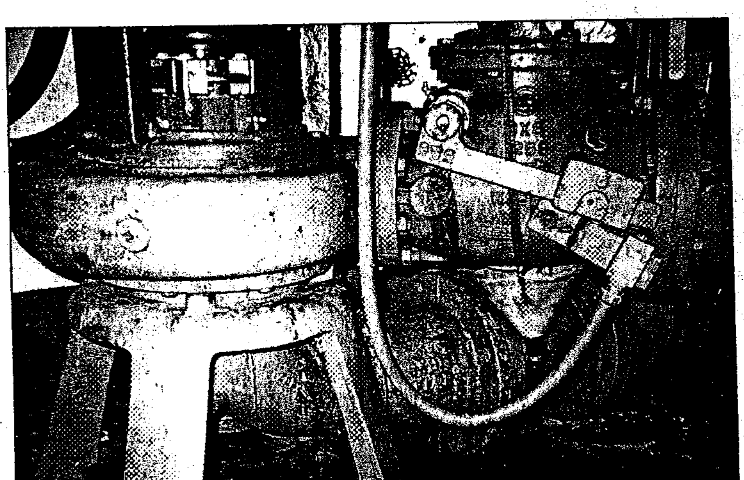
In addition to the engineers employed by the Town of Trumbull, this Showcase Demonstration project team included several consultants from ITT Flygt Corporation, the manufacturer of the new pump used in the project. ITT Flygt was also involved in the provision of pumping methodology, engineering and design of all modifications, data collection and analysis, and report writing.

Project Implementation - The Systems Approach

To identify potential energy saving opportunities at the pump station, a test plan was undertaken by team engineers. A systems approach was used to determine how to increase the efficiency of the entire sewage pumping station. Rather than focusing on the individual elements and functions of the pumping system, total system performance was the focal point of the analysis. Following a thorough investigation of the pumping system, engineers decided to add a smaller pump that could handle the same volume as the original pumps during non-peak periods. The lower outflow rate reduces friction in the piping system, lowering the required head and energy consumption.

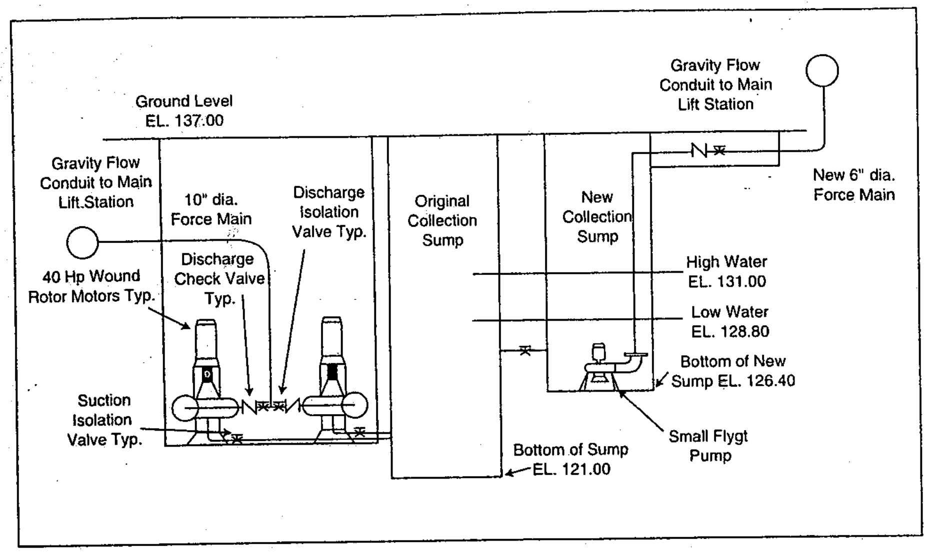
The Old System

The sizing of the pumps in the original system was designed to allow one pump to handle the entire peak inflow to the station under normal operation, which is usually less than 800 GPM. Both pumps were inactive until the level meter reached 57 inches. At that time, the primary pump would begin operating and would pump until the water level fell to 32 inches. The second pump was designed only to be used during extreme flood conditions. If the water level reached 60 inches on the level meter, the second pump would begin to operate. In flood conditions, both pumps would remain running until the water level fell to 32 inches, at which time both pumps would simultaneously shut down. Each pump rarely operated for more than five minutes at a time.



Existing 40-hp Pump

Test data for the original system indicated a normal operating point of 850 GPM at 50.3 TDH for the single operating pump. With an overall pump efficiency level of 74 percent, the pump's efficiency was not a problem. Years of use, however, had begun to take its toll on the system, resulting in frequent breakdowns, occasional flooding, and sewage spills.



New System Schematic

Engineers categorized four energy use sources in the original system: the bubbler level control system, lights, circulating pumps for the motor control system cooling water, and miscellaneous station energy use. Analysis of the pump system determined that much of the overall energy use consisted of auxiliary electrical system loads and miscellaneous point loads. Engineers found that the existing speed control system did not vary the pumps' flow handling capacity. As a result, the pumps were operating at a reduced constant speed. In addition to reducing the efficiency of the pumps' electric motors, the inefficient control system also required the constant operation of two circulating cooling water pumps. The level control system was also equipped with two continuously running compressors, further increasing electricity consumption. Finally, because of a broken automatic light switch, the three 200-watt light fixtures were constantly on.

The New System

To increase energy efficiency of the pump station, engineers installed an additional 10-hp pump with direct on-line motor starters and a level control system with float switches. The new pump handles the same volume as the original pumps during non-peak periods, but runs for longer periods of time. The lower outflow rate reduces friction and shock losses in the piping system, which lowers the required head and energy consumption.

In addition, the ineffective existing pump speed control was eliminated and the motors were wired for direct on-line start. Because the speed control was eliminated, the motors powering the existing pumps ran at 1750 RPM instead of 1320 RPM, so their impellers were trimmed from 11.25 inches in diameter to 10 inches. The existing pumps are still used for the infrequent peak flows that the new smaller pump can't handle. The two compressors for the bubbler level control system and the two circulating pumps for the old motor control system were also eliminated.

Results

Under normal conditions, the operating point for the new pump is 450 GPM at 40.7 TDH, compared to 850 GPM at 50.3 TDH for the pumps in the original system. The specific energy of the optimized system was measured at 325 kWh/MG, a 255 kWh/MG decrease from the original system. In addition to the 17,643 kWh of energy savings achieved by modifying the pump unit, significant energy savings also resulted from changes made to other energy use sources in the station. Annual energy consumption by the lighting system was reduced from 5,256 kWh to 78 kWh, while energy consumption of the bubbler level control (7,300 kWh/yr) and the cooling water pumps (1,752 kWh) was entirely eliminated. In all, 31,875 kWh was saved, a reduction of almost 44 percent, resulting in $2,614 in annual energy savings.

In addition to energy savings, the modifications reduced the system's cleaning and maintenance requirements as well as the control subsystem's maintenance requirements. Together, these reductions significantly decreased the labor needs of the station. Finally, the expected life of the operating equipment and electrical switchgear increased with the longer operating times and reduced power input of the new system.

Lessons Learned

Several lessons were learned from this Showcase Demonstration project which can be applied to other similar energy efficiency projects in the future: (1) rethinking the pump selection and operating methodology for pumping equipment can result in significant savings; (2) in systems with static head, stepping of pump sizes for variable flow rate applications can decrease energy consumption; (3) a "systems approach" can identify sources of energy consumption other than pumps that can be modified to save energy.

Performance Improvement Summary	
Energy and Cost Savings	
Project Implementation Costs	$12,000
Annual Energy Cost Savings	$2,614
Simple Payback (years)	4.6
Demand Savings (kW)	12.2
Annual Energy Savings (kWh)	31,875
Total Annual Emissions Reductions	
CO_2	40,200 lbs
Carbon Equivalent	11,000 lbs
SO_x	230 lbs
NO_x	54 lbs
PM10	5 lbs
CO	6 lbs
VOC	1 lb

About Motor Challenge

The Motor Challenge is a joint effort by the U.S. Department of Energy (DOE), industry, motor systems equipment manufacturers and distributors, and other key stakeholders to put information about energy-efficient electric motor system technology in the hands of people who can use it.

Showcase Demonstration Projects target electric motor-driven system efficiency and productivity opportunities in specific industrial applications. They show that efficiency potential can be realized in a cost-effective manner and encourage replication at other facilities.

DOE provided technical assistance and independent performance validation (IPV) of energy savings. A DOE-sponsored IPV team reviewed the test plan and provided assistance, as requested by the host site, on testing procedures, instrumentation techniques, and data acquisition. The DOE team developed a detailed IPV Report thoroughly documenting the project. The Report is available by calling the number listed below. DOE did not witness the actual test data, and the conclusions in this case study are based solely on data provided by the host site and their partners.

For more information on becoming involved in the Motor Challenge or sponsoring a Showcase Demonstration, call the Motor Challenge Information Clearinghouse at (800) 862-2086.

December 1997

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MOTOR CHALLENGE

ORNL/MC-CS8

MOTOR CHALLENGE

Showcase Demonstration CASE STUDY

a Program of the U.S. Department of Energy

THE CHALLENGE: SAVING ENERGY AT A SEWAGE LIFT STATION THROUGH PUMP SYSTEM MODIFICATIONS

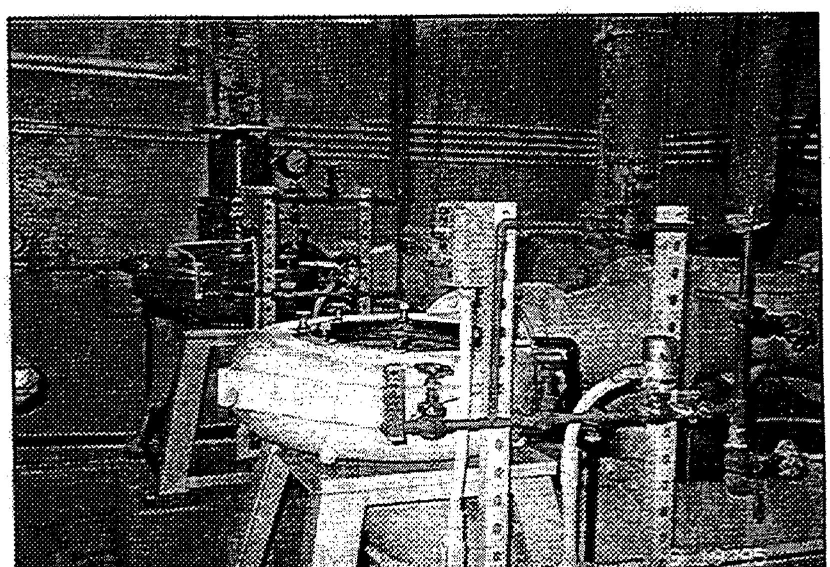
Summary

The City of Milford wanted a way to save energy at the Welches Point sewage lift station. By adding a small booster pump to the sewage pumping system, the city reduced the station's annual energy consumption by 36,096 kWh which resulted in annual savings of $2,960. This Motor Challenge Showcase Demonstration project resulted in the City of Milford reducing energy consumption by over 15 percent at their Welches Point pump station. With a total implementation cost of $16,000, the project yielded a simple payback of 5.4 years. The lessons learned from this project will be applied to other sewage stations throughout the city.

Project Profile	
Industry:	Sewage System
Process:	Sewage Pumping
System:	Pump System
Technology:	Booster Pump, Energy-Efficient Motor

Background

The City of Milford, located just south of New Haven, Connecticut, operates 37 sewage stations that serve more than 48,000 people. More than 7 million gallons of raw sewage is transported each year to one of two city sewage treatment plants.



Welches Point Sewage Lift Station

Project Overview

A medium-sized sewage station built in 1963, the Welches Point pump station handles approximately 750 million gallons of raw sewage per year and consumes an estimated 240,000 kWh of electricity annually. It is one of many stations located throughout the City of Milford delivering sewage to the local treatment plants. The system operates with three identical 75-hp pumps which are vertically mounted 40 feet below ground level. The pumps

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DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA are driven by motors positioned directly above each pump at ground level. Each pump is equipped with a 35-foot floating line shaft that pumps raw sewage to a common header which gradually steps up to ground level. From the common header, the sewage flows through the gravity feed header (shared by several sewage stations) to the main treatment plant. To evaluate the system's efficiency, an analysis of volume flow, operating times, and energy use of the pumps was performed by the Showcase Demonstration team.

City of Milford, Connecticut

SIC: 4952

Services: Sewage Pumping

Location: Milford, Connecticut

Employees: 26

Showcase Team Leader: Art Berube

Company Energy Philosophy: Changes in energy conservation must take place without any detrimental effects on system reliability. Conservation and reliability go hand in hand in the wastewater field.

Project Team

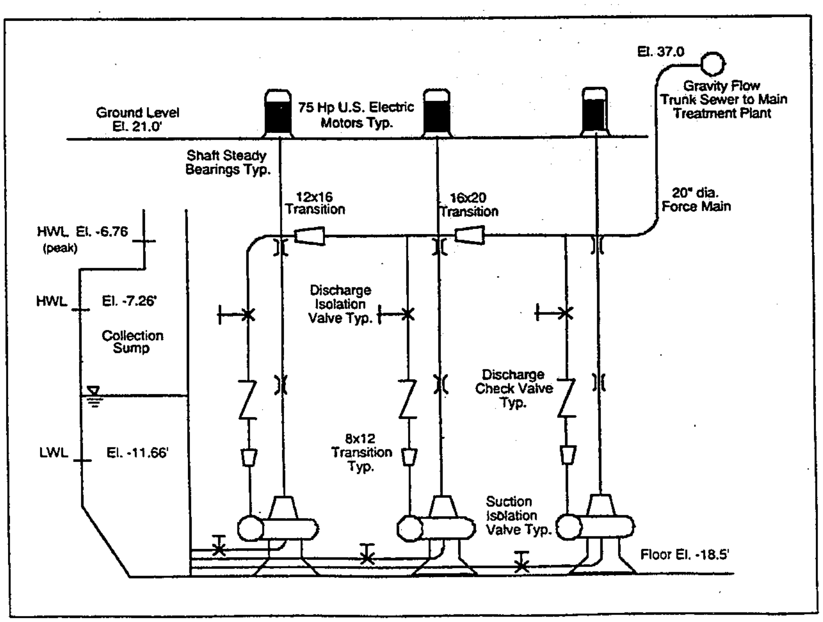
In addition to the sewage engineers employed by the City of Milford, the Showcase Demonstration project team included several consultants from ITT Flygt Corporation, the manufacturer of the new pump used in the project, and United Illuminating Company (the local electric utility) which provided electric metering services.

Project Implementation - The Systems Approach

To determine whether or not energy savings could be realized at the lift station, team engineers developed a test plan based upon the systems approach. The systems approach is a way to increase the efficiency of an electric motor system by shifting the focus away from the individual elements and functions to total system performance. After performing an analysis of the overall performance of the station's pumping system, the project team concluded that reducing pump capacity could achieve significant energy savings.

The Old System

The old system was designed to operate with only one pump under normal conditions. One of the pumps begins operating when the water level reaches a set high-water level and remains on until the water drops to a designated low-water level. During periods with very heavy inflow rates, two pumps operate simultaneously. A third pump functions as a back-up pump, operating if another pump is damaged or in repair. Each pump rarely operates for more than 15 minutes during each cycle.

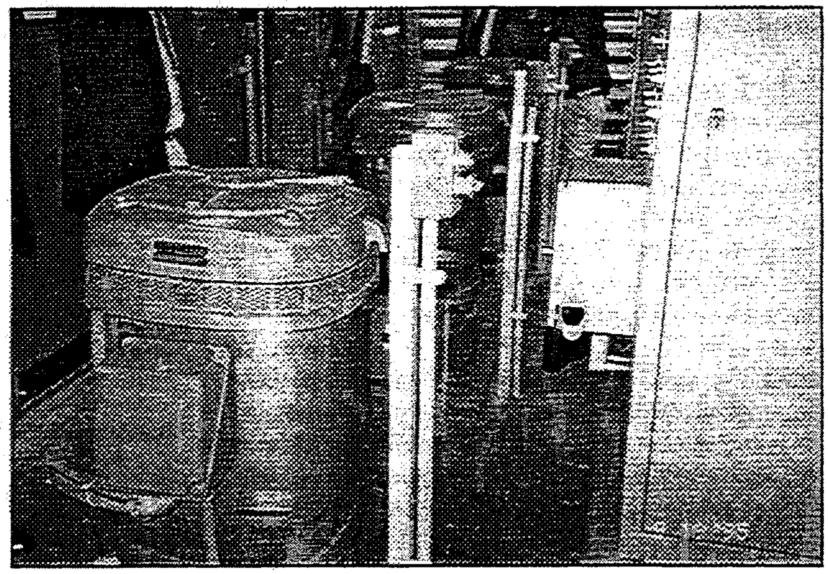


Welches Point Pump Station Schematic

The sewage station was designed to handle peak inflow of 3,000 gallons per minute (gpm). The average inflow rate of sewage is 1,700 gpm. Average flow rates from the station to the local treatment plant were estimated at 3,350 gpm during normal conditions and 4,250 gpm when two pumps operate. Each year, the old system consumed approximately 212,064 kWh of electricity to handle 752 million gallons of sewage. Overall system efficiency was rated at 73 percent. To increase the efficiency level of the system, alternatives were considered based on the volume flow rates of the system.

Alternatives Considered

Several alternatives to improve sewage station efficiency were considered. All



Sewage Pump

centered around finding a way to pump the water out of the sump more slowly, which would reduce dynamic head loss, friction in the piping system, and energy consumption. To reduce the outflow rate, engineers considered installing variable frequency drives (VFDs) on each of the pumps to allow for variable speed control. VFDs can save energy in applications involving fast or frequent changes in flow rates. Because the sump acted as a buffer in this application, the outflow rate did not need to be changed frequently, so VFDs were not the answer. Also, VFDs are not generally recommended for systems with large static heads, like this one. Other options explored involved trimming the impeller or replacing the original pumps. After analyzing the tests performed on the original pumping units, the team concluded that the best solution would be to install a smaller pump to operate at lower outflow rates for longer running periods.

The New System

The new system includes a smaller 4" x 8" pump that replaced one of the original three pumps. The smaller pump is driven by a 35-hp motor. This pump operates for longer periods, one to two hours on average, but at a lower outflow rate. The lower outflow rate results in reduced friction in the piping system, which reduces energy consumption. The original two pumps will no longer operate under normal conditions, but will run during periods with heavy inflow rates.

Results

The optimized system delivers sewage to the main treatment plant at an average flow rate of 1,930 gpm under normal conditions. Energy consumption after installing the smaller pump is estimated to be 175,968 kWh per year resulting in a reduction of more than 37,000 kWh each year. Compared to the old system, the new system reduces annual energy use by more than 15 percent, equivalent to $2,960 in annual energy savings. With a total project implementation cost of $16,000, the City of Milford will realize a simple payback of 5.4 years.

In addition to the energy savings achieved, other direct benefits from modifying the system include increased equipment life and reduced equipment downtime and repair. Frequent starting and stopping of the pumps contributes significantly to wear-and-tear of the equipment and increases the associated maintenance required. With the new system, less stress is placed on equipment.

Why Adding a Small Booster Pump Saved Energy

Sewage lift stations are simple sump systems. Water enters into the sump, and when it reaches a predetermined level, the pump turns on and empties the reservoir. A larger pump will generally use more energy than a smaller one because it will operate at a higher outflow rate. The higher outflow rate increases friction losses in the piping, which results in more energy being consumed to pump each gallon of water. Adding the small booster pump to the Milford Station allowed the system to operate at greatly reduced outflow rates during normal conditions, reducing energy consumption significantly.

Lessons Learned

In modifying the sewage station, the City of Milford not only saved energy, it also learned several important lessons that can be applied to other city energy efficiency projects: (1) New energy saving opportunities may be discovered when using a total systems performance methodology. By utilizing this methodology, the City of Milford found an innovative solution to reduce energy use; (2) Additional energy savings may be achieved by adjusting pumps to allow for variable flow rate application. In this project, stepping of pumps led to a significant increase in overall operational efficiency; (3) Replacing the original motors with energy-efficient motors also helps to reduce energy consumption.

Performance Improvement Summary	
Energy and Cost Savings	
Project Implementation Costs	$16,000
Annual Energy Cost Savings	$2,960
Simple Payback (years)	5.4
Demand Savings (kW)	30
Annual Energy Savings (kWh)	36,096
Total Annual Emissions Reductions	
CO_2	45,481 lbs
Carbon Equivalent	12,404 lbs
SO_x	266 lbs
NO_x	61 lbs
PM10	6 lbs
CO	7 lbs
VOC	1 lb

About Motor Challenge

The Motor Challenge is a joint effort by the U.S. Department of Energy (DOE), industry, motor systems equipment manufacturers and distributors, and other key stakeholders to put information about energy-efficient electric motor system technology in the hands of people who can use it.

Showcase Demonstration Projects target electric motor-driven system efficiency and productivity opportunities in specific industrial applications. They show that efficiency potential can be realized in a cost-effective manner and encourage replication at other facilities.

DOE provided technical assistance and independent performance validation (IPV) of energy savings. A DOE-sponsored IPV team reviewed the test plan and provided assistance, as requested by the host site, on testing procedures, instrumentation techniques, and data acquisition. The DOE team developed a detailed IPV Report thoroughly documenting the project. The Report is available by calling the number listed below. DOE did not witness the actual test data, and the conclusions in this case study are based solely on data provided by the host site and their partners.

For more information on becoming involved in the Motor Challenge or sponsoring a Showcase Demonstration, call the Motor Challenge Information Clearinghouse at (800) 862-2086.

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Contact:
Motor Challenge Information
Clearinghouse (800) 862-2086
www.motor.doe.gov

MOTOR CHALLENGE

ORNL/MC-CS6

Internet Resources for Energy Efficiency

Air Compressors

Energy Efficient Air Compressors
http://www.compair.com/

Evaluating Compressor Efficiency
www.maintenanceresources.com/ReferenceLibrary/AirCompressors/kaeserpage7.htm

Compressed Air: Taming Industries Monster Energy Eaters
http://www.energy.state.or.us/eamth01/Bus/aircompress.htm

Compressed Air Best Practices
http://www.oit.doe.gov/bestpractices/compressed_air/

Compressed Air Challenge
http://www.compressedairchallenge.org/

Buildings

Advanced Buildings
www.advancedbuildings.com

Cogeneration

The Association of Cogeneration, Boiler, and Refrigeration Professionals
www.nebulae.net/cobra/
The Association provides a newsletter on new power generation and the central heating industry for updated information about changing technology. Their website also provides links, a career center, and information on training.

Energy Efficient Lighting

Lighting
http://www.eren.doe.gov/EE/buildings_lighting.html

Lighting Energy Efficient Opportunities in Hotels
http://www.ase.org/programs/lighting.htm

MaxLight Industries Energy Efficient Lighting Links
http://www.maxilight.com.au/links.html

Energy Management

Federal Energy Management Program
http://www.eren.doe.gov/femp/

Understanding Management System for Energy 2000
http://www.industry.gatech.edu/energy/default.htm

EPA

Environmental Protection Agency Energy Star Program
www.energystar.org/
The Energy Star Program offers businesses and consumers with energy efficient solutions to help save money and protect the environment. This site provides tools for analyzing your current energy use, and estimating your savings.

EnviroSense
www.epa.gov/envirosense/index.html
Enviroene, part of the U.S. EPA's web site, provides a single repository for pollution prevention, compliance assurance, and enforcement information and data bases. Our search engine searches multiple web sites (inside and outside the EPA), and offers assistance in preparing a search.

Energy Brokers

Alliance Energy Services
http://www.fma-aes.com/
Alliance Energy Services, a general partnership between Conoco Inc. and Alliance Gas Services, Inc., markets natural gas and supplies electricity and transportation services, as well as, providing complete customer volume management. The majority of their customers are commercial and industrial users, municipalities, local distribution companies, utilities and cogeneration facilities. Alliance does this through the aligning of natural gas industry experience, national and regional supply and transportation expertise, and common customer service philosophies of both companies' management and staff.

Sigcorp Energy Services
http://sigcorpenergy.com/
Sigcorp Energy Services is a wholly owned subsidiary of Vectren Corporation, an energy and related applied technology company. Vectren's affiliated energy utility, technology and financial companies offer services that improve efficiency, reduce costs and provide customers with comprehensive energy solutions. Besides offering customers natural gas and electricity, Sigcorp also offers energy cost tracking and reporting, price risk management, asset optimization of supply, storage, capacity, and alternative fuels capacity, etc.

Energy Purchasing

Electricity Daily
www.electricity-online.com
The Electricity Daily is the most comprehensive information service covering every event and aspect of the North American electricity market.

Energy Purchasing Experts
www.epex.cc
EPEX is an independent energy procurement consultant that advises companies in purchasing electricity, natural gas, oil and propane to maximize their energy cost savings. EPEX principals are energy industry experts, having recently left the utility industry. EPEX has helped its clients save millions of dollars through both regulated and competitive retail electricity and natural gas negotiations.

Natural Gas

AGL Resources
www.aglresources.com
The second largest natural gas only distributor in the United States.

Williams Energy
www.williamsenergy.com
Provides trading in all U.S. markets 24 hours a day, 7 days a week.

Canadian Gas Research Insitute
www.cgri.ca
The Canadian Gas Research Institute (CGRI) is an independent not-for-profit research and development organization with a mandate to develop leading edge technology for the natural gas industry.

Enron Companies
www.enron.com

Ferrell Gas
www.ferrellgas.com

Intermarket Trading Company
www.itcoworld.com

Kinder Morgan Inc
www.kne.com

LG&E Energy
www.lgeenergy.com

Metromedia Energy
www.metromediaenergy.com

Mobil Oil Corporation
www.mobil.com
Murphy Oil Corporation
www.murphyoilcorp.com

National Fuel Gas
www.natfuel.com

NIPSCO
www.nisource.com

Production Gathering Company
www.pgcgas.com

ProLiance Energy
http://proliance.com

Texaco OnLine
www.texaco.com

The Energy Source Network
www.naturalgas.com

General

Alliance to Save Energy
www.ase.org

The Alliance to Save Energy is a coalition of prominent business, government, environmental, and consumer leaders who promote the efficient and clean use of energy worldwide to benefit consumers, the environment, economy, and national security.

National Resources Defense Council
www.nrdc.org
The Natural Resources Defense Council's purpose is to safeguard the Earth: its people, its plants and animals and the natural systems on which all life depends.

CERES (Coalition for Environmentally Responsible Economies)
www.ceres.org
The leading U.S. coalition of environmental, investor, and advocacy groups working together for a sustainable future including a community of forward-looking companies that have committed to continuous environmental improvement by endorsing the CERES Principles, a ten-point code of environmental conduct.

American Council for an Energy Efficient Economy
www.aceee.org
The American Council for an Energy-Efficient Economy is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection.

American Hydrogen Association
www.clean-air.org
The goal of AHA is to stimulate interest and help establish the renewable hydrogen energy economy by the year 2010. Find resources on fuel cells and new energy efficiency technology on this page.

Association of Energy Engineers
www.aeecenter.org/index.html
This site provides information on membership to the association, certification, online journals, chapters, and links.

Association of Energy Services Professionals International
www.aesp.org
The Association of Energy Services Professionals is dedicated to advancing the professional interests of individuals working to provide value through energy services and energy efficiency by the sharing of ideas, information and experience.

Canadian Sustainable Energy Systems
www.newenergy.org
Here you can find information to help you produce and/or use energy in the most effective and environmentally-friendly ways possible.

Energy Ideas Clearinghouse BBS
www.energy.wsu.edu/ep/eic/
The Energy ideas page is full of resources including links, energy solutions, a library and even jobs.

Industries of the Future
Software Tools
http://www.oit.doe.gov/bestpractices/software_tools.shtml

Renewable Energy Policy Project and the Center for Renewable Energy and Sustainable Technology
http://solstice.crest.org/index.html
REPP-CREST's goal is to accelerate the use of renewable energy by providing credible information, insightful analysis, and innovative strategies amid changing energy markets and mounting environmental needs.

Sempra Energy Solutions
www.aeecenter.org
Sempra Energy Solutions mission is to act with urgency to lead the transformation of the retail energy markets by creating innovative solutions that revolutionize the customer experience. For more information on saving up to 40% on your annual energy bill visit this site.

The Center for Energy Efficiency and Renewable Technologies
www.cleanpower.org
CEERT is a unique collaboration of major environmental organizations, public interest groups and clean technology companies working to achieve a more sustainable energy future.

The Northwest Energy Efficiency Alliance
www.nwalliance.org
The Northwest Energy Efficiency Alliance works to make energy-efficient products and services available and affordable to the northwest region's consumers.

World Energy Efficiency Association
www.weea.org/
The World Energy Efficiency Association web page provides a large listing of resources for energy efficiency on the web. Their site also includes reports and publications, regional information, and a message board.

Motor and Pump Energy Efficiency

Tips for Lowering Your Heat Pump's Energy Usage
www.eren.doe.gov/buildings/consumer_information/heatpump/pumplower.html

Institute of Diagnostic Engineers
Improving Motor Efficiency
http://www.diagnosticengineers.org/B5-18.htm

Federal Energy Management Program
Adjustable Speed Motor Drives
http://www.energy.wsu.edu/cfdocs/tg/2.htm

Energy Ideas
Pumping Systems
www.energyideas.org

Pumping Systems Assessment Tool (PSAT)
Downloadable version
http://www.oit.doe.gov/bestpractices/software_tools.shtml

U.S. Department of Energy

Department of Energy (DOE)
www.energy.gov
The Department of Energy website has information and resources on many issues including energy issues and your health, house, transportation, school, business, community, world and the future.

Energy Efficiency and Renewable Energy Network (EREN)
www.eren.doe.gov/
This Department of Energy web page has resources on energy efficiency and renewable energy information, including many links and pertinent documents.

National Energy Research Supercomputing Center
www.nersc.gov/
NERSC is a world leader in accelerating scientific discovery through computation. NERSC provides high-performance computing tools and expertise that enable computational science of scale, in which large, interdisciplinary teams of scientists attack fundamental problems in science and engineering that require massive calculations and have broad scientific and economic impacts.
NERSC is funded by the Department of Energy, Office of Science, and is part of the Computing Sciences Directorate at Lawrence Berkeley National Laboratory. High-speed remote access to NERSC is provided by ESnet.

ESnet

www.es.net

The Energy Sciences Network, or ESnet, is a high-speed network serving thousands of Department of Energy scientists and collaborators worldwide. A pioneer in providing high-bandwidth, reliable connections, ESnet enables researchers at national laboratories, universities and other institutions to communicate with each other using the collaborative capabilities needed to address some of the world's most important scientific challenges.